

**Water Quality at
Stevens Island
and Indian Bay,
Shoal Lake, Ontario
(June 29 and July 5, 1989)**

By A.E. Beck



WATER QUALITY
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ONTARIO
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Manitoba Environment
Water Standards and Studies Report #89-5

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SUMMARY

A multijurisdictional inspection of the Consolidated Professor Mines Limited development on Stevens Island, Shoal Lake was conducted on June 29, 1989. Apart from the oil and fuel storage area, the site appeared reasonably well maintained and organized and compared well with similar enterprises currently operating in Manitoba.

A limited water and sediment sampling program was conducted in conjunction with the inspection. Analytical results revealed that loadings of arsenic, nickel, sulphate, phosphorus and uranium to Shoal Lake were occurring as a result of minewater discharges from the Consolidated Professor Mines Limited development on Stevens Island. However, these loadings were minor with respect to both volumes and concentrations discharged and excepting uranium, have not resulted in detectable change in Shoal Lake at a point even 5 metres directly offshore from the mouth of the effluent stream. Uranium was not detectable at a point 20 metres directly offshore from the mouth of the effluent stream. Sediment analysis suggested that minewater discharges may have contained trace quantities of copper, lead and zinc but there was no evidence that these metals had been discharged to Shoal Lake. Prior to its discharge to Shoal Lake, the quality of the minewater effluent stream met both Canadian Water Quality Guidelines and Manitoba Surface Water Quality Objectives established for human consumption.

Extensive water sampling conducted July 5, 1989 on a randomized block basis confirmed that the water from Indian Bay and from the vicinity of Stevens Island constituted an acceptable source of potable supply. There was no evidence of impact from minewater discharges upon the water quality of Indian Bay, the source of potable supply to the City of Winnipeg.

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1.0 BACKGROUND

Consolidated Professor Mines Limited is in the process of developing the Duport Gold property, with surface structures and the associated ore concentrator to be located on Stevens Island. This development has aroused concerns about the protection of the water supply for the City of Winnipeg because the City of Winnipeg draws its water supply from Indian Bay of Shoal Lake. Indian Bay straddles the Manitoba-Ontario border while most of the remaining surface area of Shoal Lake falls entirely within Ontario. Stevens Island, located centrally on Shoal Lake, is approximately twelve kilometres (by water) from the City of Winnipeg water intake structure (Figure 1).

A multi-jurisdictional* inspection of the Consolidated Professor Mines Limited development on Stevens Island was conducted on Thursday, June 29, 1989. The inspection tour was arranged by Mr. John Barr (Ontario Ministry of Environment) and the party was guided by Mr. Dick Dunlop (Consolidated Professor Mines Limited). The inspection involved the entire area of Stevens Island that had been developed by Consolidated Professor Mines Limited. Original workings (i.e. Duport Mine developments commencing circa 1897) on nearby Little Cameron Island were not inspected.

* The inspection party consisted of:

Manitoba Environment - Mr. Al Beck; Mr. Bryan Blunt
Manitoba Department of Health - Dr. Bev Rutherford
Manitoba Department of Energy and Mines - Mr. Dave Cook
Ontario Ministry of Environment - Mr. John Barr; Ms Hilary Mills
Ontario Ministry of Northern Development and Mines
- Mr. Charles Blackburn
City of Winnipeg - Mr. Trevor Hutchinson; Mr. Tom Pearson;
Mr. Arnold Permut

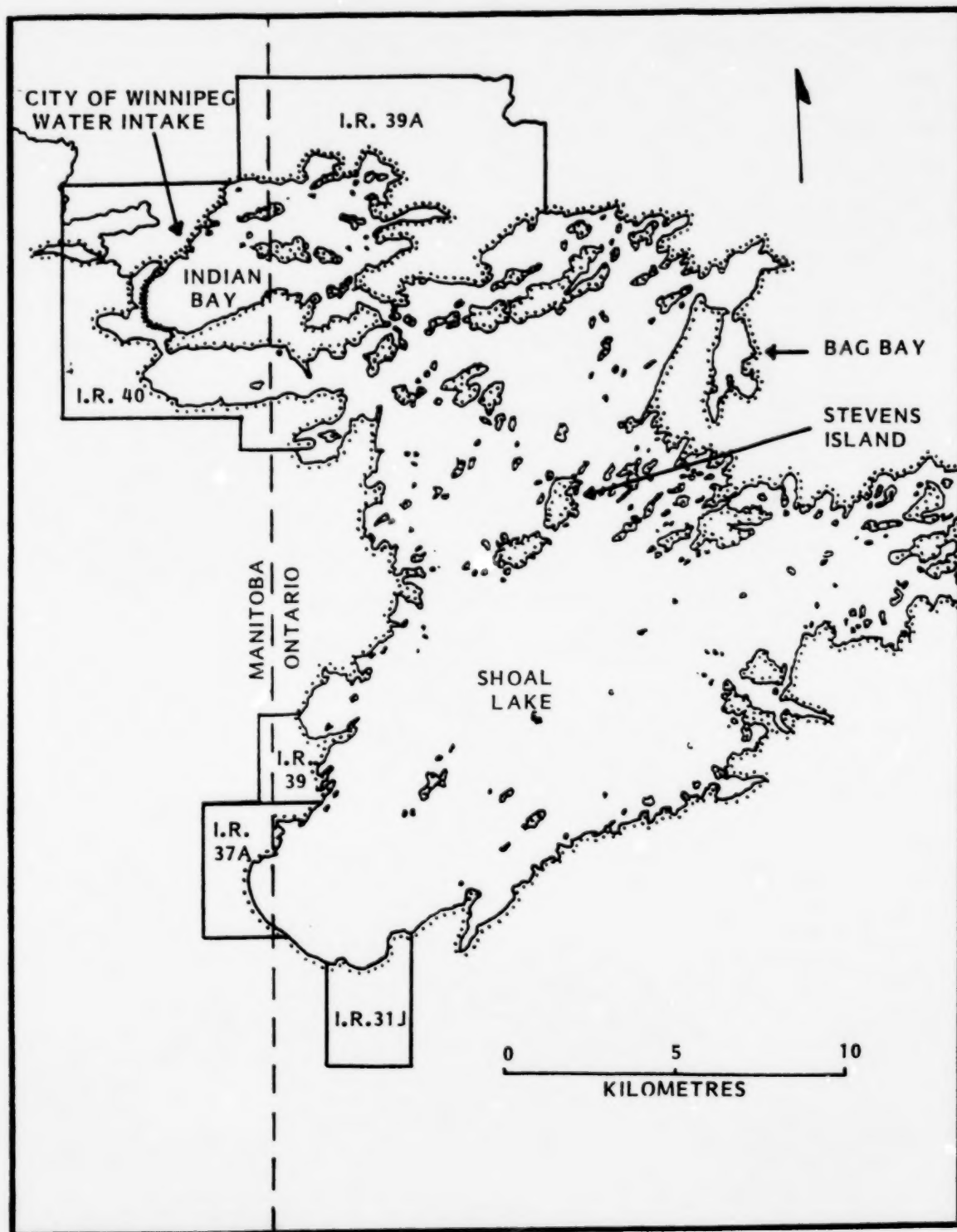


FIGURE 1: Significant features of Shoal Lake, Ontario.

The purpose of the present report is to provide observations on general conditions at the Stevens Island site as well as to present analytical results of the water and sediment sampling conducted at Stevens Island on June 29, 1989. Results of the water sampling conducted near Stevens Island and at Indian Bay on July 5, 1989 are also presented. The present report is not intended as a definitive statement of Shoal Lake water quality since only one sampling interval at each of the two general areas is documented. No attempt has been made to compare present data to historical information provided by Ontario Ministry of Environment, by Consolidated Professor Mines Limited or by the City of Winnipeg.

2.0 STEVENS ISLAND SITE DESCRIPTION

Waste rock, consisting primarily of diorite, a dark coloured igneous rock, has been used as a base for site leveling and construction of access roads. The waste rock was derived from the 1350 metre long decline (i.e. downward slanting tunnel which provides access to the orebody). Two waste rock stockpiles, roughly 50 m x 150 m x 8 m in dimension, are located south-westerly and north-easterly of the decline, respectively (Figure 2). The tops of each stockpile are leveled but sloped towards the decline. Muck (shattered ore) from exploratory blasts into the orebody is stockpiled atop each of the waste rock piles.

Major structures present include an older two-storey "staff house" (currently undergoing renovation), and two single storey frame buildings which presumeably comprise a bunkhouse and a tool-workshed. Also present is a large metal building which will be used as a machine shop. Lesser structures include a number of locked core sheds, a salvaged conduit stockpile and a 3-tank fuel depot. The fuel depot is surrounded by a clay berm.

The entrance to the decline is sealed from the public by a bolted, welded steel plate.

Two minewater* settling ponds are located on Stevens Island approximately 250 metres south-westerly of the decline. These ponds measure approximately 6 m x 12 m x 1.2 m in dimension.

* Minewater consists of natural groundwater infiltration as well as surface water used to cool mining drills.

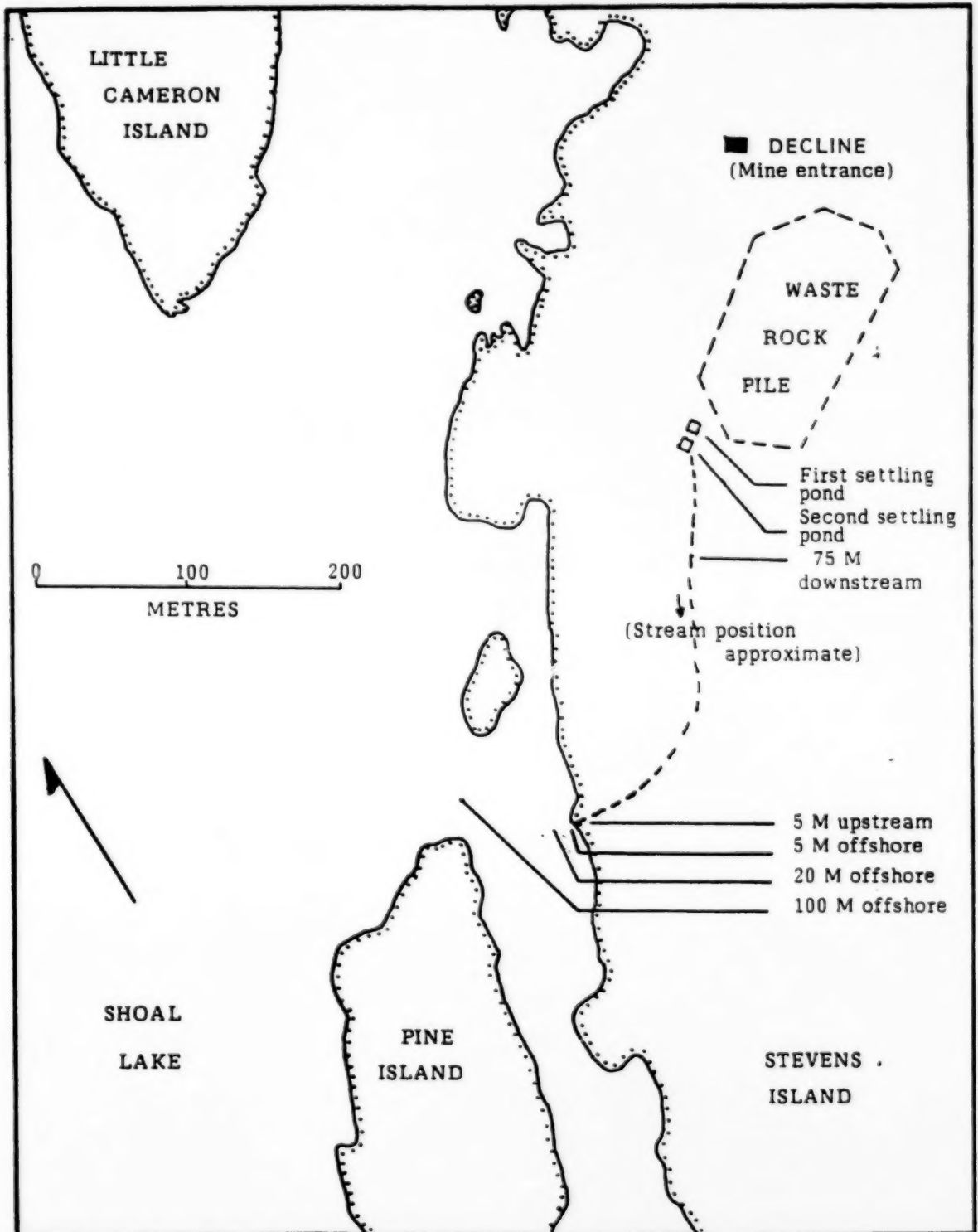


FIGURE 2: Minewater settling pond, effluent stream and Shoal Lake water sampling stations, west side of Stevens Island (June 29, 1989).

Currently, the mine "makes water" at a rate of approximately 350 litres per minute (Mr. Dick Dunlop, pers. comm.); presumably the rate of minewater discharge was similar*. The settling ponds discharge to Shoal Lake via a minor stream (partly ditch, partly natural depression) of approximately 250 metres in length (Figure 2).

Tailings, which are waste materials resulting from ore processing, were not present on Stevens Island.

The site was reasonably well organized and maintained. Litter control was not a problem. However, the oil and fuel storage area could have benefited from some upgrading. In general terms, the Stevens Island site compared well with most mines currently operating in Manitoba.

* The mine is not currently in operation and is not discharging minewater to the settling ponds.

3.0 SAMPLING METHODS

3.1 Rationale

The strategy adopted for the present study was to firstly inspect the Stevens Island site to identify all current potential sources of contamination to Shoal Lake. Secondly, water and sediment sampling was to be conducted at all potential sources of contamination identified during the inspection, as well as those areas of Shoal Lake potentially at risk from such contaminant discharges. Thirdly, an extensive set of randomized water samples were to be collected from the vicinity of Stevens Island and from Indian Bay in order to provide "background" data.

The sole area identified as a current potential source of contamination to Shoal Lake was the mine water disposal system. This system consists of two settling ponds and the associated discharge stream flowing to Shoal Lake (Figure 2). The waste rock was not considered a potential source of contamination because diorite is regarded as inert in aquatic systems. (Diorite comprises much of the bedrock naturally outcropping along the shores of Shoal Lake.) Stockpiled ore also was not considered a potential source of contamination because of its comparatively small volume and because of the natural vegetation (i.e. coniferous and mixed deciduous forest) buffer zone between the ore stockpiles and the shore of Shoal Lake. The septic field sewage disposal system was not considered a potential source because leakage was not observed during the inspection*.

* The septic field had not been subject to heavy use since underground development work was suspended.

Accidents such as fuel spills were considered beyond the scope of the current study. This was because risk analysis procedures can provide an estimate of the frequency of occurrence. Background water quality data from both the Ontario Ministry of Environment data base and from the current study would permit accurate assessments of impact.

3.2 Sampling on June 29, 1989

Split sampling of water was conducted with Mr. John Barr, Ontario Ministry of Environment. Duplicate water and sediment samples were collected from each settling pond and from two locations on the effluent stream (Figure 2). These stream locations were approximately 75 metres downstream of the second settling pond and approximately 5 metres upstream of the point of discharge to Shoal Lake, respectively. Surface samples from Shoal Lake were collected at points approximately 5 metres, 20 metres and 100 metres offshore from the mouth of the settling pond stream. Bottom water samples were collected from the 20 metre and 100 metre offshore sites as well. A bottom water sample was not collected from the 5 metre offshore site since the surface sample was fully representative of the shallow depth encountered (i.e. less than 1 m). Duplicate sediment samples were collected from the 20 metre offshore site. A single sample was collected from the 100 metre offshore site. Rock bottom prevented a full collection of sediment samples.

Surficial water samples at 50 and 100 metre offshore intervals were collected from a bay on the east side of Stevens Island (Figure 3). These were considered "background" since the site is the proposed receiving area for Consolidated Professor Mines Limited tailings decant. Surficial water samples were collected by immersion

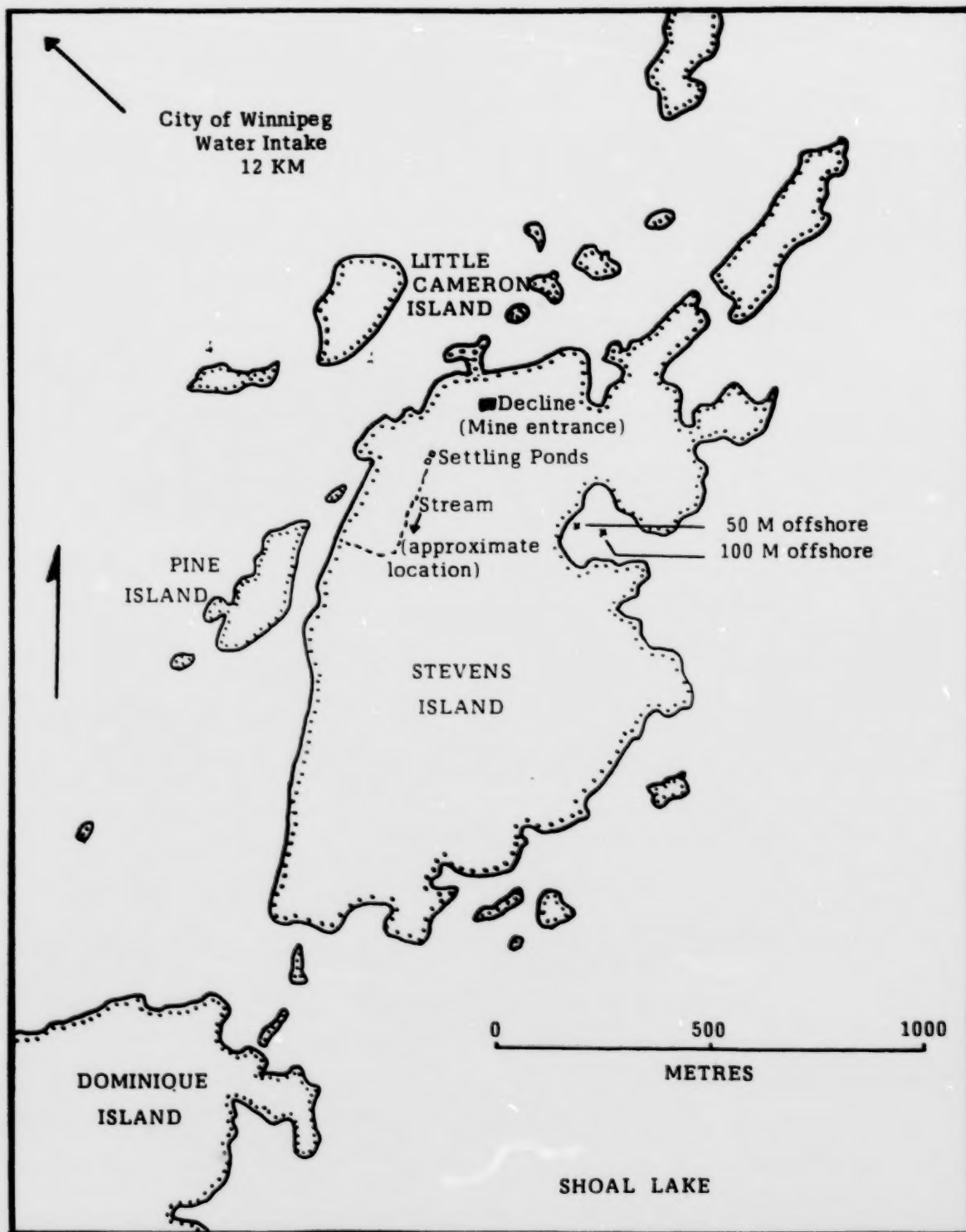


FIGURE 3: Water sampling locations on east side of Stevens Island, Shoal Lake (June 29, 1989).

of laboratory precleaned sample bottles; whereas samples at depth were collected with a trace metal grade Kemmerer sampler. Sediment samples were collected with a 15 cm square Ekman dredge.

3.3 Sampling on July 5, 1989

Two sampling blocks were established for background purposes. The first block consisted of a circular area measuring approximately three kilometres in radius from the centre of Stevens Island (Figure 4). The second block consisted of Indian Bay (Figure 5). Sampling stations were determined by superimposing a numbered grid upon a figure of each block and utilizing random number tables to select grid reference points. A total of 15 grid reference points were thus selected as random sampling stations for the Stevens Island block (Figure 4) and 10 for the Indian Bay block (Figure 5).

Water samples were collected at random depths with a trace metal grade Kemmerer sampler. Sampling depths for all stations were determined by considering random numbers (0-9) as the depth (metres) from which samples were to be collected.

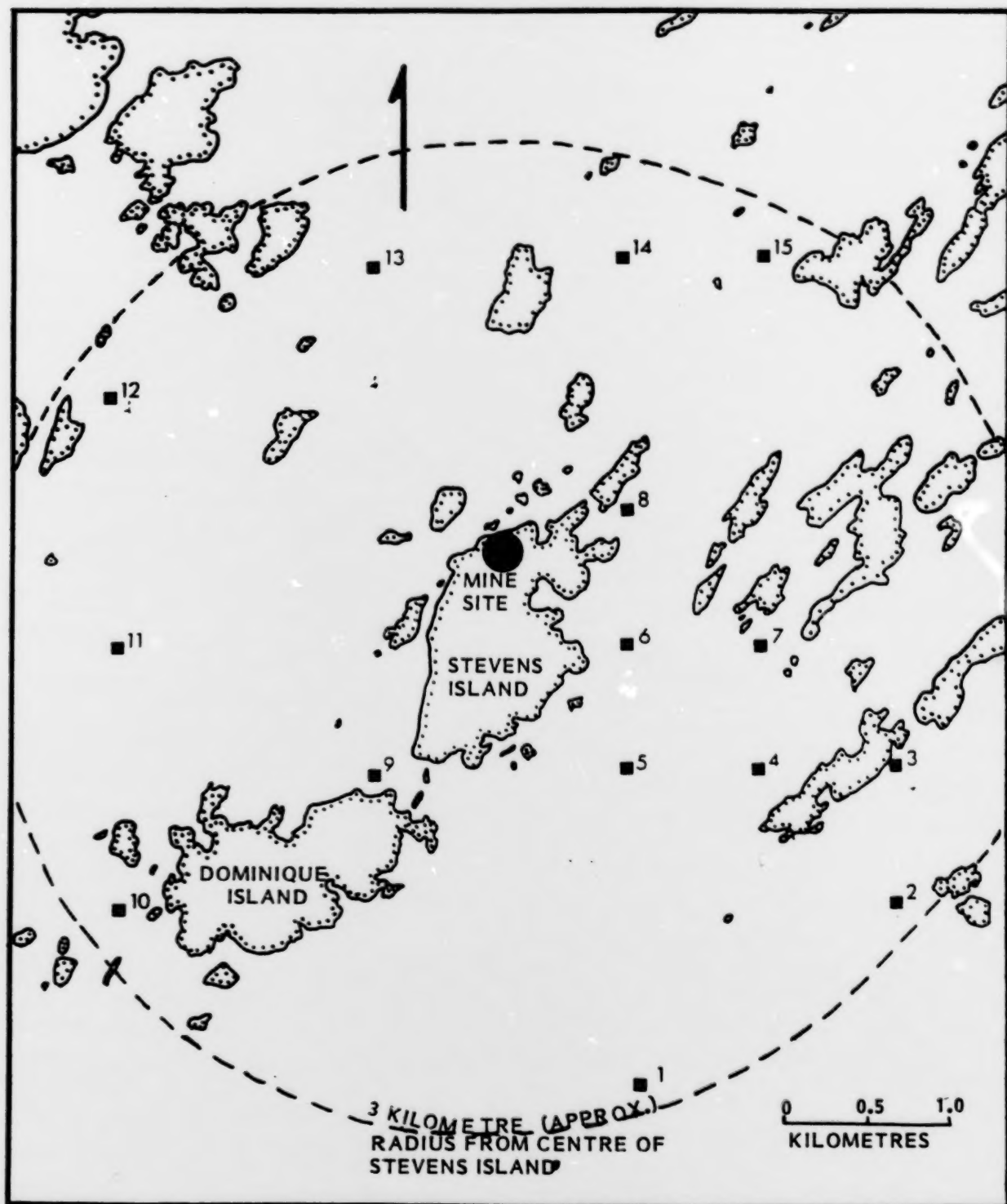


FIGURE 4: Random sampling stations (#1-15) for background water chemistry at Stevens Island, Shoal Lake (July 5, 1989).

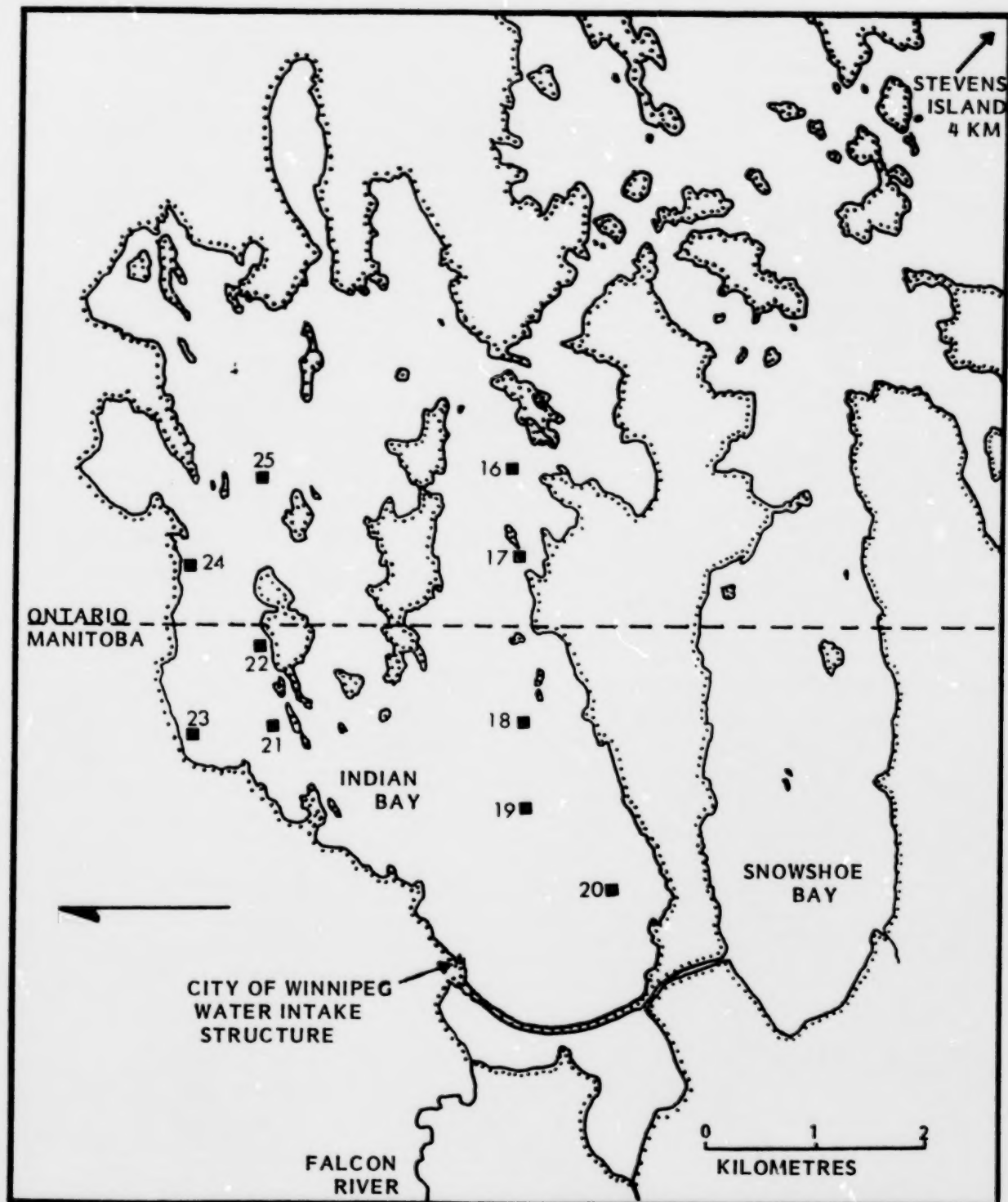


FIGURE 5: Random sampling stations (#16-25) for background water chemistry at Indian Bay, Shoal Lake (July 5, 1989).

4.0 RESULTS AND DISCUSSION

4.1 The Mine Site

Analytical results for water samples collected June 29, 1989 are presented in Table 1. Analytical results for sediment samples collected June 29, 1989 are presented in Table 2.

4.1.1 Arsenic and Heavy Metals

Total* arsenic concentrations in water from the first settling pond averaged 0.263 mg/L** whereas the second pond averaged 0.146 mg/L. Arsenic concentrations 75 metres downstream of the second pond were approximately 25% of initial values. This indicates that most arsenic present in the minewater occurs in particulate form. The particulate fraction is readily removed by settling and is generally not available for ingestion and accumulation by aquatic organisms. Arsenic concentrations 5 metres upstream of the discharge to Shoal Lake (average of 0.027 mg/L) were well within both Canadian Water Quality Guidelines and Manitoba Surface Water Quality Objectives*** established for human consumption (i.e. 0.05 mg/L). This means that even prior to dilution in Shoal Lake, the June 29, 1989 arsenic

* "Total" includes dissolved forms as well as suspended sediment particles (i.e. silt particles).

** "mg/L" or milligrams per litre is equivalent to ppm or parts per million.

*** Williamson, D. A. 1988. Manitoba Surface Water Quality Objectives. Water Standards and Studies Section. Manitoba Department of Environment and Workplace Safety and Health. Winnipeg. 47 pp.

Table 1: SHOAL LAKE - STEVENS ISLAND WATER CHEMISTRY, June 29, 1989.

Parameters*	Location		First Settling Pond		Second Settling Pond		Stream, 75 M Downstream of 2nd Pond		Stream 5M Upstream of Shoal Lake	
	A	B	A	B	A	B	A	B	A	B
Conductivity ($\mu\text{mho/cm}$)	475	475	476	479	986	941	741	742		
Total Residue (mg/L)	310	320	330	320	820	820	630	630		
Filterable Residue (mg/L)	310	320	330	320	810	810	630	620		
Non Filterable Residue (mg/L)	<5	<5	<5	<5	6	12	<5	7		
pH (Units)	7.62	7.84	7.62	7.63	7.04	7.05	6.93	6.94		
Total Alkalinity (mg/L)	242	239	228	227	136	140	94.7	93.7		
Bicarbonate Alkalinity (mg/L)	295	292	278	277	166	171	116	114		
Carbonate Alkalinity (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Hydroxyl Alkalinity (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Colour (Units)	40	40	25	25	>50	>50	>50	>50		
Turbidity (NTU)	1.75	1.56	1.07	0.90	2.2	3.3	0.55	0.65		
Hardness (mg/L)	213	219	211	210	460	470	360	360		
Arsenic (Total mg/L)	0.268	0.258	0.146	0.146	0.066	0.067	0.026	0.028		
Cadmium (Ext. mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Mercury (Ext. $\mu\text{g/L}$)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		
Copper (Ext. mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
Zinc (Ext. mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
Lead (Ext. mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		
Nickel (Ext. mg/L)	0.006	0.005	<0.005	<0.005	0.006	0.006	0.005	0.005		
Uranium (Ext. $\mu\text{g/L}$)	0.62	0.69	0.85	0.79	0.49	0.61	0.55	0.49		
Iron (Ext. mg/L)	0.19	0.18	0.11	0.10	0.17	0.19	0.11	0.10		
Manganese (Ext. mg/L)	0.04	0.05	0.04	0.04	0.12	0.13	0.02	0.03		
Calcium (Ext. mg/L)	42.9	44.4	43.7	43.4	136	139	100	100		
Magnesium (Ext. mg/L)	25.7	26.3	24.9	24.9	29.2	29.7	26.8	26.8		
Potassium (Ext. mg/L)	>5	>5	>5	>5	>5	>5	>5	>5		
Sodium (Ext. mg/L)	22.1	22.1	22.7	22.9	24.9	24.7	21.1	21.5		
Total Kjeldahl-N (mg/L)	1.35	1.20	1.00	0.95	2.50	2.65	1.35	1.25		
Ammonia-N (mg/L)	0.016	0.009	0.014	0.015	0.180	0.200	0.018	0.015		
Nitrate-Nitrite-N (mg/L)	0.02	0.01	0.01	0.01	9.00	10.0	1.32	1.60		
Total Phosphorus (mg/L)	0.095	0.095	0.074	0.075	0.155	0.180	0.057	0.056		
Chloride (mg/L)	1.3	1.0	2.1	2.2	2.6	2.6	2.2	2.3		
Sulphate (mg/L)	25	25	35	30	310	340	285	280		
Silicon Dioxide (mg/L)	1.7	1.7	3.7	3.8	5.5	5.8	6.8	6.8		

* "<" denotes "less than" detection, ">" denotes "greater than".

Table 1: SHOAL LAKE - STEVENS ISLAND WATER CHEMISTRY, June 29, 1989 (continued).

Parameters*	Location	Shoal Lake 5 M Off Stream Surface	Shoal Lake 20 M Off Stream Surface	Shoal Lake 100 M Off Stream Surface	Shoal Lake 50 M SE Stevens Is. Surface	Shoal Lake 100 M SE Stevens Is. Surface
Conductivity ($\mu\text{mho/cm}$)		166	165	164	161	163
Total Residue (mg/L)		110	110	100	100	100
Filterable Residue (mg/L)		110	110	100	100	100
Non Filterable Residue (mg/L)		<5	<5	<5	<5	<5
pH (Units)		7.88	7.64	7.74	7.75	7.77
Total Alkalinity (mg/L)		79.2	78.8	78.1	78.8	78.4
Bicarbonate Alkalinity (mg/L)		96.6	96.1	96.6	96.1	95.6
Carbonate Alkalinity (mg/L)		0.0	0.0	0.0	0.0	0.0
Hydroxyl Alkalinity (mg/L)		0.0	0.0	0.0	0.0	0.0
Colour (Units)		5	5	5	5	5
Turbidity (NTU)		0.53	0.65	0.79	0.78	0.62
Hardness (mg/L)		78.3	78.0	78.6	79.5	75.7
Arsenic (Total mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Ext. mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001
Mercury (Ext. $\mu\text{g/L}$)		<0.02	<0.02	<0.02	<0.02	<0.02
Copper (Ext. mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Ext. mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Ext. mg/L)		<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (Ext. mg/L)		<0.005	<0.005	<0.005	<0.005	<0.005
Uranium (Ext. $\mu\text{g/L}$)		0.05	<0.05	<0.05	<0.05	<0.05
Iron (Ext. mg/L)		<0.02	<0.02	<0.02	<0.02	<0.02
Manganese (Ext. mg/L)		<0.02	<0.02	<0.02	<0.02	<0.02
Calcium (Ext. mg/L)		20.6	20.5	21.0	21.5	20.5
Magnesium (Ext. mg/L)		6.39	6.50	6.35	6.20	6.00
Potassium (Ext. mg/L)		>5	>5	>5	>5	>5
Sodium (Ext. mg/L)		2.58	2.46	2.44	2.44	2.40
Total Kjeldhal-N (mg/L)		0.50	0.45	0.60	0.45	0.50
Ammonia-N (mg/L)		0.007	0.008	0.010	0.006	0.010
Nitrate-Nitrite-N (mg/L)		0.01	<0.01	<0.01	<0.01	<0.01
Total Phosphorus (mg/L)		0.009	0.010	0.011	0.010	0.011
Chloride (mg/L)		1.5	1.5	1.4	0.80	0.95
Sulphate (mg/L)		3.95	4.80	3.80	3.50	3.50
Silicon Dioxide (mg/L)		0.7	0.7	0.7	0.7	0.7

* "<" denotes "less than" detection

Table 2: METAL RESIDUES IN SEDIMENTS AT STEVENS ISLAND, June 29, 1989

Parameters*	Location		First Settling Pond		Second Settling Pond		Stream, 75 M Downstream of 2nd Pond		Stream 5M Upstream of Shoal Lake	
	A	B	A	B	A	B	A	B	A	B
Total Arsenic (µg/g)	279	417	457	156	33.3	74.1	22.2	23.9		
Total Cadmium (µg/g)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		
Total Copper (µg/g)	184	208	126	106	30.8	51.0	15.9	15.2		
Total Lead (µg/g)	33.7	37.3	36.5	34.1	11.7	17.5	9.35	10.4		
Total Mercury (µg/g)	0.02	0.07	0.03	0.05	0.05	0.03	0.02	0.02		
Total Nickel (µg/g)	180	198	156	135	26.2	58.7	19.1	17.6		
Total Zinc (µg/g)	228	252	450	228	48.1	96.6	114	122		
Total Iron (%)	5.75	2.95	2.44	2.52	2.50	3.09	1.89	2.01		
Total Manganese (µg/g))	1450	1390	1080	1140	206	447	297	340		

Parameters*	Location		Shoal Lake 20 M Off Stream		Shoal Lake 100 M Off Stream	
	A	B	A	B	A	B
Total Arsenic (µg/g)	1.27	1.35			1.40	
Total Cadmium (µg/g)	<0.5	<0.5			<0.5	
Total Copper (µg/g)	1.91	2.26			1.62	
Total Lead (µg/g)	1.15	2.90			1.62	
Total Mercury (µg/g)	<0.02	<0.02			<0.02	
Total Nickel (µg/g)	3.82	3.87			3.25	
Total Zinc (µg/g)	10.7	10.3			9.1	
Total Iron (%)	0.26	0.27			0.30	
Total Manganese (µg/g))	65	77			81	

* "<" denotes "less than detection"

concentrations in water did not exceed objectives set for human consumption. Arsenic was not detected in any of the water samples collected from Shoal Lake. This means that although minewater discharges are loading arsenic to Shoal Lake, the discharges to date have not elevated arsenic concentrations to a detectable level (i.e. 0.001 mg/L) even 5 metres offshore from the mouth of the effluent stream. Sediment analytical results supported the interpretation of analytical results for water samples.

Cadmium was not detected in any water or sediment samples from the settling pond, the effluent stream or from Shoal Lake. Thus there was no evidence of minewater loadings of cadmium to Shoal Lake.

Copper and lead were not detected in any of the water samples collected June 29, 1989. However, progressively declining concentrations were detected in samples of sediment from the settling ponds, the stream and the lake, respectively. The inference was that trace levels of copper and lead likely were present in minewater discharged to the settling ponds. Sediment data provided no evidence that detectable quantities of copper and lead had been discharged to Shoal Lake.

Traces of mercury (0.02 µg/L)* were detected in one of the duplicate stream samples approximately 75 metres downstream of the second settling pond and in the bottom water samples from 20 metres offshore the stream mouth. These results are suggestive of slight contamination by stirred sediments rather than of loadings by

* "µg/L" or micrograms per litre is equivalent to ppb or parts per billion.

minewater. (Note that the sensitivity of the mercury analysis is 50 times greater than the arsenic or cadmium analyses.) Regardless of the source of the detected mercury, results were well within both Canadian Water Quality Guidelines and Manitoba Surface Water Quality Objectives established for human consumption (i.e. 1.0 µg/L). Sediment analytical results yielded little further information since the trace quantities detected were more indicative of organic content than of a minewater source.

Traces of nickel (0.005 to 0.006 mg/L) were detected in water samples from the first settling pond and from each of the stream samples. Nickel was not detected (minimum detection limit 0.005 mg/L) in water from either the second settling pond samples or in any of the samples from Shoal Lake. This indicated that minewater discharges were loading trace quantities of nickel to Shoal Lake but that such loadings have not resulted in detectable nickel concentrations even 5 metres offshore from the mouth of the effluent stream. Sediment results were supportive of this interpretation. Nickel is not of concern with respect to human consumption; however, concentrations greater than approximately 0.076 mg/L might begin to impact aquatic organisms in Shoal Lake. Given the trace concentrations present in even the first settling pond, nickel loadings do not appear to pose a threat to Shoal Lake.

Zinc was detected in both water samples collected from the effluent stream approximately 5 metres before discharge to Shoal Lake. Failure to detect zinc in water at any site upstream of this point, including the first settling pond, implied that the source was natural. However, progressively declining concentrations detected in

sediments from the settling ponds, stream and lake, respectively, suggested that minewater discharges could not be dismissed as a potential source of trace zinc loading.

Uranium was detected in all water samples from Stevens Island as well as in the Shoal Lake sample collected approximately 5 metres offshore from the stream mouth. (This latter value was 0.05 $\mu\text{g/L}$, the minimum level of detection.) It was clear that discharge of minewater was the source of uranium detected. The maximum value encountered, 0.85 $\mu\text{g/L}$ in the second settling pond, was within the objective guideline (i.e. less than or equal to 1.0 $\mu\text{g/L}$) established for drinking water supplies by Health and Welfare Canada. Detection of uranium in minewater was not surprising since it is routinely detected in groundwater samples collected from the Precambrian Shield.

4.1.2 General Chemistry

General water chemistry parameters include conductivity, pH, the residues, the alkalinities, iron, manganese, sodium, chloride, sulphate, hardness, calcium, magnesium, turbidity and colour.

Conductivity, a measurement of the ability to conduct electrical current, provides an indication of the relative amount of dissolved minerals present in the sample. There are no direct implications for either human consumption or for aquatic organisms. Samples from the settling ponds were lightly mineralized as conductivity was approximately three times greater than in Shoal Lake samples. Stream samples were mineralized to a greater degree as conductivity was approximately 4.5 to 6 times greater than in samples from Shoal Lake. The inference drawn was that increased conductance in the stream was attributable to natural inflows from surrounding wetlands.

The pH value provides an indication of acidity. Values below 7.0 represent acidic conditions and values greater than 7.0 represent alkaline waters. Values between 6.5 and 8.5 provide the best conditions for aquatic organisms. All values encountered during the present study fell within the preferred range. Values from the settling ponds were similar to pH values in Shoal Lake samples. Stream samples demonstrated the influence of slightly acidic natural infiltration from surrounding wetlands. (Bog drainage is typically acidic.)

Measurements of the alkalinities, calcium and magnesium provide indications of the water's ability to neutralize acidic inputs. Values encountered were considered normal for local groundwater, streams and Shoal Lake, respectively.

Sodium concentrations typically are greater in groundwater supplies than in fresh surface waters. Values encountered in the settling ponds and stream were approximately one order of magnitude greater than in Shoal Lake. Sodium values did not constitute a concern because they were well below the maximum value considered acceptable for human consumption (i.e. 400 mg/L).

Chloride values exhibited little real difference between any of the samples.

There were some indications of minor sulphate loadings to Shoal Lake. Though some of the sulphate may be attributed to groundwater seepage through pyritic ores infiltrating the mine, most of the sulphate burden appeared to be attributable to natural infiltration of water from wetlands surrounding the effluent stream.

Decomposing vegetation such as peat typically releases sulphides which are readily oxidized to sulphates. All values encountered were within levels considered acceptable for human consumption (i.e. less than 500 mg/L).

Water samples from the settling ponds and the stream were slightly more turbid than samples collected from Shoal Lake. The difference was not considered significant since winds could induce greater turbidities on shallow portions of Shoal Lake than were actually measured on Stevens Island.

Water samples from settling ponds were moderately coloured (25-40 units) whereas all stream samples were highly coloured (>50 units). The colour in the stream samples was attributed to natural infiltration of water containing humic acids which were derived from surrounding bog areas. The discharge of highly coloured water is common to virtually all streams draining bog areas.

4.1.3 Nutrients

Total Kjeldhal nitrogen provides a measure of organically bound nitrogen such as that present in amino acids. Thus it provides an indication of biological activity. Values encountered in the settling ponds and stream were typical of moderately productive surface waters in Manitoba. Values encountered in the Shoal Lake samples were low and indicative of a low level of biological activity.

Ammonia loadings are sometimes associated with minewater discharges when recent underground blasting has occurred. Values encountered were attributable to natural infiltration from surrounding

wetlands. Loadings from minewater were not implicated because blasting had not occurred recently and any previous discharges to the settling ponds would have had ample opportunity for oxidation to the nitrate form.

Significant loadings of nitrate to the stream were attributable to natural infiltration from surrounding wetlands. Such loadings are not unusual when peat is exposed to the atmosphere and allowed to oxidize. Interestingly, this natural infiltration raised nitrate concentrations at one site (75 metres downstream of the second settling pond) to a level considered unacceptable for human consumption (i.e. 10 mg/L). However, nitrate levels were well within acceptable concentrations prior to discharge to Shoal Lake.

Phosphorus can be of concern because it is the nutrient which most often triggers nuisance algae growth. Some minor loading of total phosphorus appeared to be attributable to minewater discharges. However, these loadings posed a negligible risk because of the volumes discharged and the phosphorus concentrations involved. Samples from Shoal Lake provided no evidence of detectable impact.

Silicon dioxide is an essential nutrient for diatoms (unicellular silica coated algae). Values encountered were considered normal.

4.1.4 Other Observations

Both settling ponds had aquatic organisms present. Tadpoles were common and larval Chaoborus were abundant. (Chaoborus are commonly known as phantom midges because the larval stage,

approximately 1.5 cm in length, is virtually transparent.) The presence of Chaoborus suggests that although a winter oxygen depletion is a common event in the settling ponds, conditions are otherwise not toxic to most aquatic organisms. A bloom of cladocerans (water fleas) was present in the effluent stream approximately 75 metres downstream of the second settling pond. The proliferation of these organisms suggested that primary production (i.e. algal growth) was not inhibited by minewater discharges.

4.2 The Stevens Island Random Sampling Block

Analytical results for water samples collected July 5, 1989 are presented in Table 3.

4.2.1 Arsenic and Heavy Metals

Arsenic, cadmium, lead, mercury and nickel were not detected in any of the samples from the Stevens Island random block. Given the comparatively high arsenic values encountered June 29, 1989 in the settling ponds, the random block data confirmed that minewater discharges did not cause detectable impact upon arsenic and heavy metal concentrations in the water surrounding Stevens Island.

Analytical results for copper and zinc were unique among the heavy metals. Copper was detected at stations 1, 2, 3, 4 and 6 (Figure 4). The highest copper value encountered, 0.04 mg/L, occurred at station 4 and concided with the single detection of zinc (0.01 mg/L). These data may have been indicative of a copper-zinc deposit in the vicinity of station 4. Discharges from Stevens Island were not

Table 3: SHOAL LAKE WATER CHEMISTRY NEAR STEVENS ISLAND, JULY 5, 1989.

Parameters*	Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Conductivity (umho/cm)		163	162	162	162	163	161	163	163	163	162	163	160	161	161	161
Total Residue (mg/L)		130	130	130	130	130	120	100	130	130	130	130	120	130	120	120
Filtrable Residue (mg/L)		130	130	130	130	130	120	100	130	130	130	130	120	130	120	120
Non Filtrable Residue (mg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
pH (Units)		7.90	7.97	8.00	8.00	8.00	8.00	8.04	8.00	7.91	7.95	7.98	7.86	7.99	7.99	8.01
Total Alkalinity (mg/L)		77.9	78.8	79.3	79.0	78.8	78.5	78.1	79.7	76.5	79.2	77.4	78.9	78.4	78.5	77.8
Bicarbonate Alkalinity (mg/L)		95.0	96.2	96.8	96.4	96.1	95.8	95.2	97.2	93.3	96.6	94.5	96.2	95.7	95.8	94.9
Carbonate Alkalinity (mg/L)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydroxyl Alkalinity (mg/L)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hardness (mg/L)		82.2	81.2	81.7	83.8	80.9	80.7	82.4	81.2	81.0	81.1	81.1	81.1	81.1	80.5	77.4
Colour (Units)		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Turbidity (FTU)		0.66	0.44	0.56	0.52	0.48	0.46	0.60	0.73	0.66	0.63	0.64	0.70	0.65	0.55	0.59
Arsenic (Total mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Ext. mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury (Ext. µg/L)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Copper (Ext. mg/L)		0.01	0.01	0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Ext. mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Ext. mg/L)		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (Ext. mg/L)		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Iron (Ext. mg/L)		0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	<0.02
Manganese (Ext. mg/L)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Calcium (Ext. mg/L)		21.9	21.7	21.8	22.3	21.6	21.7	21.9	21.6	21.6	21.6	21.6	21.6	21.6	21.4	20.5
Magnesium (Ext. mg/L)		6.68	6.61	6.62	6.76	6.55	6.50	6.66	6.59	6.58	6.60	6.60	6.60	6.60	6.56	6.37
Potassium (Ext. mg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sodium (Ext. mg/L)		2.56	2.51	2.64	2.52	2.60	2.60	2.60	2.48	2.56	2.56	2.65	2.57	2.57	2.43	2.49
Total Kjeldahl-N (mg/L)		0.50	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.55	0.45	0.45	0.55	0.45	0.45	0.50
Ammonia-N (mg/L)		0.018	0.12	0.014	0.015	0.017	0.016	0.010	0.018	0.010	0.010	0.015	0.015	0.016	0.013	0.029
Nitrate-Nitrite-N (mg/L)		0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Phosphorus (mg/L)		0.016	0.012	0.011	0.011	0.010	0.010	0.008	0.012	0.011	0.011	0.011	0.010	0.011	0.010	0.010
Chloride (mg/L)		1.4	1.4	1.4	1.5	1.4	1.4	1.3	1.4	1.4	1.4	1.3	1.3	1.4	1.4	1.4
Sulphate (mg/L)		3.20	3.40	3.35	3.30	3.35	3.40	3.45	3.40	3.45	3.45	3.50	3.35	3.45	3.50	3.60
Silicon Dioxide (mg/L)		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Sample Depth (m)		3	7	3	4	5	9	0	1	5	5	4	1	3	7	1

* "<" denotes "less than"

implicated because copper and zinc residues were not detected nearer the point of discharge (i.e. station 9) and because arsenic, the most likely candidate for detection, was not encountered.

4.2.2 General Chemistry and Nutrients

The remarkable factor about Shoal Lake water in the vicinity of Stevens Island was its uniformly excellent quality. Dissolved mineral content, as indicated by non filterable residue and conductivity, was moderately low. The alkalinities, hardness and buffering minerals (calcium, magnesium, etc.) were all indicative of moderately soft water conditions. Aesthetic factors such as colour, turbidity, iron and manganese were well below levels at which concerns might begin to develop. Nutrients were consistent with meso-oligotrophic conditions in which biological productivity is too low to impart aesthetically displeasing characteristics. There was no evidence of impact from Stevens Island minewater discharges.

4.3 The Indian Bay Random Sampling Block

Analytical results for water samples collected July 5, 1989 from Indian Bay are presented in Table 4.

4.3.1 Arsenic and Heavy Metals

Arsenic and heavy metals were not detected in any water samples from Indian Bay. Thus there was no evidence of impact from Stevens Island minewater discharges.

Table 4: SHOAL LAKE WATER CHEMISTRY AT INDIAN BAY, JULY 5, 1989.

Parameters*	Location	16	17	18	19	20	21	22	23	24	25
Conductivity (µmho/cm)		160	159	160	160	160	159	157	155	157	159
Total Residue (mg/L)		130	120	120	110	120	120	110	110	110	120
Filterable Residue (mg/L)		120	120	120	110	120	120	110	110	110	120
Non Filterable Residue (mg/L)		10	<5	<5	<5	<5	<5	<5	<5	<5	<5
pH (Units)		7.46	7.99	8.15	7.99	8.12	8.32	8.30	8.47	8.29	7.99
Total Alkalinity (mg/L)		79.0	76.7	77.6	78.0	77.0	76.5	77.6	76.3	76.5	79.8
Bicarbonate Alkalinity (mg/L)		96.3	93.6	94.7	95.2	93.7	73.4	72.4	69.1	93.3	97.3
Carbonate Alkalinity (mg/L)		0.0	0.0	0.0	0.0	0.0	9.84	10.9	11.8	0.0	0.0
Hydroxyl Alkalinity (mg/L)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hardness (mg/L)		79.9	79.0	79.5	79.9	78.7	81.4	80.8	80.6	76.0	79.7
Colour (Units)		5	5	5	5	5	5	5	5	5	5
Turbidity (NTU)		1.53	1.50	1.20	1.18	1.24	0.89	0.86	0.87	1.01	0.13
Arsenic (Total mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Ext. mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury (Ext. µg/L)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Copper (Ext. mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Ext. mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Ext. mg/L)		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (Ext. mg/L)		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Iron (Ext. mg/L)		0.26	0.07	0.06	0.08	0.08	0.04	0.05	0.04	0.05	0.07
Manganese (Ext. mg/L) 0.05		0.05	0.03	0.03	0.02	0.02	0.02	<0.02	<0.02	0.02	0.02
Calcium (Ext. mg/L)		21.2	21.0	21.1	21.3	21.0	22.0	21.8	21.5	20.1	21.5
Magnesium (Ext. mg/L)		6.49	6.32	6.42	6.42	6.36	6.42	6.40	6.45	6.20	6.24
Potassium (Ext. mg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sodium (Ext. mg/L)		3.42	2.53	2.58	2.55	2.58	2.56	2.60	2.55	2.54	2.60
Total Kjeldahl-N (mg/L)		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.65	0.50	0.55
Ammonia-N (mg/L)		0.014	0.011	0.007	0.012	0.009	0.011	0.009	0.017	0.011	0.016
Nitrate-Nitrite-N (mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Total Phosphorus (mg/L)		0.018	0.014	0.014	0.013	0.008	0.007	0.012	0.011	0.012	0.012
Chloride (mg/L)		1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.1	1.2
Sulphate (mg/L)		3.20	3.15	3.10	3.10	3.05	2.95	3.05	3.15	3.00	3.05
Silicon Dioxide (mg/L)		0.9	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.4
Sample Depth (m)		8	7	0	6	4	3.5	2	1	4	9

* "<" denotes "less than detection"

4.3.2 General Chemistry and Nutrients

The water quality of Indian Bay was very similar to that in the vicinity of Stevens Island. the minor differences observed were attributable to wind induced turbulence in the comparatively shallower mean depth of Indian Bay versus the Stevens Island area (i.e. <5 m versus >10 m, respectively). Factors affected included turbidity, iron and manganese. There was no evidence of impact from the Stevens Island minewater discharges.

5.0 CONCLUSIONS

The following conclusions pertain only to conditions which existed at the time of inspection and sampling. They may not necessarily be indicative of what might occur should the proposed development proceed.

1. Loadings of arsenic, nickel, sulphate, phosphorus and uranium to Shoal Lake were occurring as a result of minewater discharges from the Consolidated Professor Mines Limited development on Stevens Island.
2. Loadings of arsenic, nickel, sulphate, phosphorus and uranium are very minor with respect to both volumes and concentrations discharged. Excepting uranium, these loadings have not resulted in detectable change in Shoal Lake at a point even 5 metres directly offshore from the mouth of the effluent stream. Uranium was present at the minimum detection limit of 0.05 µg/L 5 metres directly offshore from the mouth of the effluent stream but was not detectable at a point 20 metres offshore.
3. Sediment analysis suggested that minewater discharges may have contained trace quantities of copper, lead and zinc, but there was no evidence that these metals had been discharged to Shoal Lake.
4. The quality of the minewater effluent stream met both Canadian Water Quality Guidelines and Manitoba Surface Water Quality Objectives established for human consumption prior to its discharge to Shoal Lake.

5. There was no evidence of impact from minewater discharges upon the water quality of Indian Bay, the source of potable water supply to the City of Winnipeg.

6.0 ACKNOWLEDGEMENTS

The organizational assistance and information provided by Mr. John Barr of the Ontario Ministry of Environment is gratefully acknowledged. Appreciation is also expressed to the City of Winnipeg and the many staff who arranged and provided logistical support and transport to and from the study areas. The extra efforts of staff of the W.M. Ward Technical Services Laboratory who provided "rush" analysis are also recognized with thanks. Mr. Tom Pearson and colleagues at the City of Winnipeg reviewed the manuscript and provided helpful comments.